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Identification of hazardous and risk assessment of energy sources for Kavir Steel Complex using ETBA method in 2015

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Abstract

Introduction: The steel industry is known as the most important consumer of energy and fuel. In doing so, ensuring safety of energy sources of a country needs to expect the risks analysis in order to select a comprehensive approach. This study aimed to identify the energy consumption and control measures available in the Hot Rolling Kavir Steel Complex and to conduct risk assessment by Energy Tracking and Barrier Analysis method (ETBA).
Materials and methods: In this study, initially a team of experts identified mobilized energies and risks of the system and control measures using ETBA sheet that result of a standard MILSTD-882B. Then, the initial risk assessment was carried out using ETBA method. Finally, the control strategies were proposed and the secondary risk level was calculated.
Results: Using ETBA, in total 19 energy types and 74 risk types were successfully identified so that in the first stage, 19 risks were unacceptable, 50 risks were unfavorable and 5 risks were acceptable for which the corrective strategies were required Then, the corrective revisions were proposed to reduce the risk level and calculate RAC2.
Conclusion: Corrective controlling measures including safety, health and environmental training, continual monitoring and ongoing visit are effective using the safety equipment and personal protective equipment for reducing the unacceptable risks.

Keywords: Kavir Steel Complex, Energy Trace and Barrier Analysis (ETBA), Risk assessment, Energy

Introduction

The increasing development of technology in the modern age, the needs to use energy and some dangerous chemicals in industries have led to increase accidents and consequently, heavy human, economic and environmental damages on the industry and its environment. Examination of factors and identification of prone disasters and dangerous spots in an organization are important in order to keep track of incidents. Risk in projects refers to the unknown contingent events or conditions which are effective on the objectives of the project in an event as positive or negative consequences. Each of these events or conditions have specific causes and distinguishable consequences. The implications of these events indirectly influence time, cost and quality of project (1). Risk assessment is a logical method to identify and evaluate risks and their potential consequences on people, materials, equipment and environment (2). The applications of risk assessment include analysis of various scenarios in environmental disasters at chemical and manufacturing plants as well as urban densely populated areas, coastal ports and in ports with commercial shipping activities, power plants, chemical and crude oil transfer and storage equipment which are vulnerable against natural disasters, industrial accidents or terrorism(3,4). Today, a variety of methods is used to identify and evaluate risks such as Energy Trace and Barrier Analysis (ETBA) (5). Steel industries are considered as one of the most important customers of a country's energy and fuel due to their production processes. Energy is mainly consumed in the steel manufacturing processes related to fossil fuels (i.e. gas, coal, oil, gas) and electricity, so this industry is considered as a part of the Energy Intensive Industries (EII) (6) which may fail to adopt the safety measures to maintain and use safety risks which will be followed by irreparable events. ETBA method is formed based on such a logic that damage resulting from an accident arises due to unwanted exchanges which occur during the energy flows from the barrier to the exposed objectives. Energy tracking and barrier performance is a qualitative analysis which is used to develop more detailed hazards. In this method, the risks are discovered using trace principle of energy flows in the systems or operations (7). This method is one of the most useful and informative tools available for researchers to assess safety of the systems. In this technique, the incident is defined as an unintended release of energy that occurs as a result of inadequate Barriers (8).

Centous et al., (2010) state that one of the most important methods of risk assessment in industrial processes is evaluation of the control systems used in these processes that is considered in the ET & BA method (9). Mandela et al., (2014) argue management of safety risks is something beyond addressing the human mistakes and factors examined for energy sources while the corresponding control layers must be considered carefully to achieve more effective control methods. Their article also refers to the use of ET & BA in risk control. Also, their study points out that, a large proportion of accidents can be controlled by monitoring the energy resources (10). Nejad Ali et al., assessed safety of LPG spherical tank using FMEA and FTBA methods in a petrochemical industry, in total, 30 components were evaluated, and each case was evaluated qualitatively, in total, 10 risks were obtained unacceptable, 7 cases were undesirable, 8 risks were acceptable which need to be revised, and 5 risks were acceptable without such a need (1).

Mortazavi et al., identified and assessed safety of the danger centers (unwanted energy streams) in a petrochemical plant using ET & BA method. In their study, a total of 144 focus of risk were identified of which 68% were in high-risk zone, 30% were in the important risk zone and 2% were in moderate risk zone (12). In order to study hazard identification and risk assessment in central heating system of Shahid Beheshti Hospital using ETBA, Sarsangi et al. identified a total of 8 power and 35 potential risks of which 12 risks were unacceptable, 20 cases were unfavorable and 35 ones were acceptable while the highest level of risk was related to chemical energy and electricity (13). Therefore, given the great diversity of energy used in Kavir steel complex, this study was carried out to identify risk potential in energy sources used in Kavir Steel Complex and prevent the potential accidents using the ET and BA technique.

Materials and methods

This study was carried out using the qualitative method in Kavir Steel Complex in the city of Aran and Bidgol in 2015. This process of industry is hot-rolled, its raw material is billet and rebar is the final product.

Originally, an ETBA worksheet for energy information was designed which included name and type of used energy, potential targets, impact, inventory control method, initial risk level, corrective control method, secondary risk level. The results of this worksheet are recorder and presented in Table 3

Stages of this study are as follows:1) Formation of an expert team composed of HSE personnel, technical engineers and technical technicians of the departments associated with the production; 2) Identification of the energy types in this system; 3) Tracking energies flowing in system (review and analysis of energy consumption and the facilities requiring energy).

Above mentioned stages were implemented in the activity field (field visit) by interviews with personnel and reviewing records of incidents related to equipment, relevant technical documents and ETBA worksheet. Therese activities involve following types of energy and factors: electrical energy, mass, gravity, height, kinetic energy, rotation, humidity, vibration, energy from chemicals, pressure, volume, and heat energy which is emitted as a result of activity or material consumption.

Initial assessment of guards and barriers to prevent unintended release of energy (review existing control measures and re-calculated risk level) is an example of such barriers as walls, fences, insulation, protective shields, warning signs, and instructions on how to do safe work, work experience and monitoring supervisor.

Providing the proposed control strategy and calculation of risk-secondary level: The risk matrix included in MIL-STD-882E standard was used to determine the risk level. This method is formed of tables of the risk, risk probability and matrix related to the recent combination of factors and evaluation criteria. The severity of the risk table is a classified description of the risk level which is expressed on the basis of real or perceived risk potential to create damage or injury. MIL-STD-882E Standard presents classification of the severity of the risk in a variety of disastrous, critical, frontier, and minor disasters. The table of the probability of a hazard provides a qualitative judgment criterion about the relative probability of occurrence of the uncontrolled hazard, and is classified into a variety of frequent, probable, casual, unlikely and improbable risks. Risk assessment matrix is a matrix which combines the elements of the risk severity table and the risk probability table, and has provided an effective tool to estimate acceptable and unacceptable levels of risk (a quantitative matrix in a range of 1-24). In order to use the risk assessment matrix, the likelihood and severity of risk must be inserted in appropriate categories and must follow a purely subjective method. Regarding the evaluation criteria, the MIL-STD-882E standard provides four indices of judgment and decision making including high, medium, low and negligible(12).

Table 1. Risk matrix (according to ETBA) according to the MIL-STD-882E standard.

The probability of risk	The severity of the risk			
	Disastrous (1)	Critical (2)	Frontier (3)	Frontier (4)
Frequent (A)	1A	2A	3A	4A
Probable (B)	1B	2B	3B	4B
Casual (C)	1C	2C	3C	4C
Unlikely (D)	1D	2D	3D	4D
Implausible (E)	1E	2E	3E	4E

Table 2. Classification of risks in the study.

Risk index	Risk classification
unacceptable	1A, 1B, 1C, 2A, 2B, 3A
Undesirable	1A, 2C, 2D, 3C, 3B
Acceptable with need to revise	1E, 2E, 3D, 3E, 4B, 4A
Acceptable without need to revise	4C, 4D, 4E

Results

In total, 19 energy types were identified after studying existing energy sources in Kavir Steel Complex, which could lead to 50 different types of risk to humans, environment and work equipment (Table 3). By examining the potential and kinetic energies resulting from the activities and operations of the complex, 24 risks were identified in accordance with Table 4.
The risk levels were determined in two steps, initially due to inventory control method, 25.6% of the risks were in the unacceptable range, 67.5% of risks were in the unfavorable range and 6.7% of them were in the acceptable range with a need to revise. In the second step, the revisions were proposed by experts to reduce the risk level which was expected to be decreased in accordance with the proposed revisions compared to previous values so that 14.86% of risks would be in the unfavorable range, 58.10% of them would be in the acceptable range with a need to revise and 27.02% of the risks would be in the acceptable range with no need to revise. Frequency of risks is shown in Figure 1.

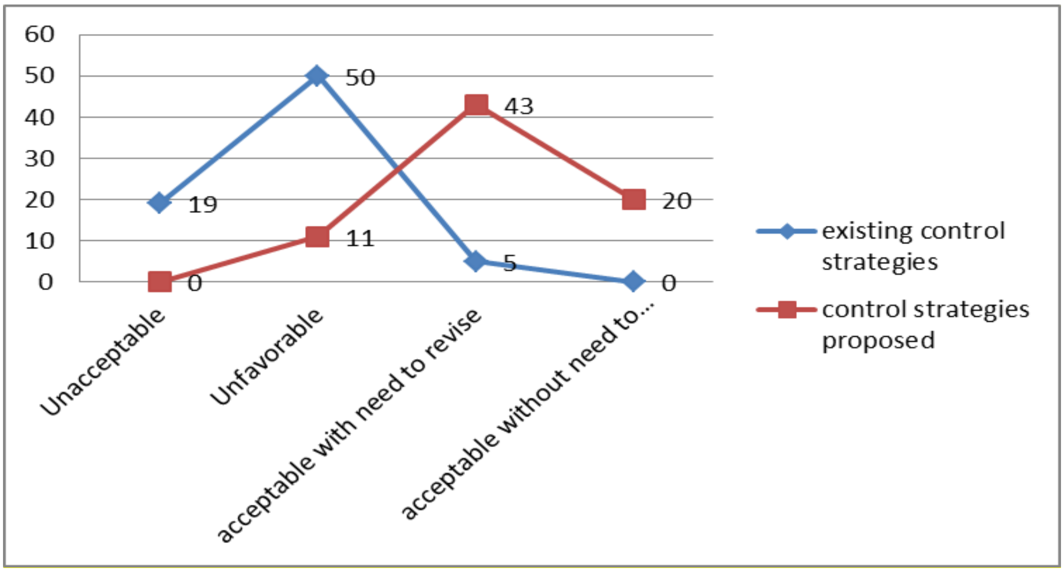

Figure 1. Comparison of risk level in existing control strategies and control strategies proposed.

Table 3. Risks related to energy resources in the Kavir Steel Complex.

Energy Name	Kind of energy	Potential targets	The primary risk level	Secondary risk level
Chemical energy	Gasoline	Man	2A	4E
		Equipment	2B	3E
		Environment	2A	4D
	Methane	Man	2C	3D
		Equipment	2C	3D
		Environment	3C	3D
	Liquid gas	Man	3C	3D
		Equipment	3C	3D
		Environment	3C	3D
	Hydraulic oil	Man	2B	3C
		Equipment	2C	3D
		Environment	2B	3C
	Nitrogen	Man	3C	3D
		Equipment	2C	3D
		Environment	3D	3E
	Oxygen cylinders	Man	3C	3D
		Equipment	2C	3D
		Environment	3D	3E
	CO_2 Gas cylinders (Fire Fighting)	Man	3C	3D
		Equipment	2C	3D
		Environment	3D	3E
	Steam	Man	3A	4B
		Equipment	2A	3C
		Environment	1A	3C
Electricity	Electrical panel	Man	2C	3E
		Equipment	2C	3E
		Environment	2C	3E
	Power transformer	Man	1B	3D
		Equipment	2C	3E
		Environment	2C	3E
	MV Room	Man	2C	3E
		Equipment	2C	3E
		Environment	2C	3E
	Electricity	Man	2C	3E
		Equipment	2C	3E
		Environment	2C	3E
	Lighting devices	Man	2B	3D
		Equipment	2B	3D
		Environment	2C	3D
Voice	Voice	Man	2A	3C
		Environment	2A	3C
Heating and cooling	Heat	Man	2B	3D
		Equipment	2B	3C
		Environment	2B	3C
	Cooling	Man	3C	3D
		Equipment	3C	3D
		Environment	3C	3D
Radiation	Infrared	Man	2C	3D
	UV	Man	2C	3D
	Electromagnetic waves	Man	2C	3D

Table 4. Identification and assessment of risks related to potential and kinetic energy in production of Kavir Steel complex.

Energy Name	Kind of energy	Potential targets	The primary risk level	Secondary risk level
Potential energy	Hanging objects	Man	3C	4D
		Equipment	3D	4E
	Uneven surfaces	Man	2B	4D
	Stairs and greasy and slippery surfaces	Man	2B	4D
	Manholes and ducts	Man	2C	4D
	Stairs and mobile Elevators	Man	3C	4E
	Transport of chemicals	Man	3C	4D
		Equipment	3C	4D
		Environment	2C	4D
	Product twisting (exit Fittings runner)	Man	2B	3C
		Equipment	3C	4D
		Environment	3C	4D
	Carrying	Man	3C	4D
		Equipment	3C	4D
		Environment	3C	4D
	Washing tanks	Man	2C	3E
		Equipment	3C	4D
		Environment	3C	4E
	Washing fat	Man	2C	3C
		Equipment	3C	4D
		Environment	2C	3D
	Handling rebar	Man	2C	3C
		Equipment	3D	4D
		Environment	3D	4D

Discussion

The results showed that 92% of the risks are in an unacceptable and unfavorable range. This result is consistent with Sarsangi et al., where hazard identification and risk assessment of central heating system of Shahid Beheshti hospital were conducted using ETBA method such that more than 90 % of energy risks were in an unacceptable range (13). This is also in line with Mortazavi et al., where identification and assessment of unwanted energy streams safety were conducted in a petrochemical plant using ET & BA and consequently 98% of risks were in a high and important range (12). However, safety assessment of spherical tanks was carried out by Nejad Ali et al., using FMEA and ETBA on petrochemical industry in which about 56% of risks were in the critical range (11). Such a difference in results is due to differences in type of the review process, establishment of safety management, the studied environment. In a study carried out by Omidvar and Rahmani on risk assessment of safety in power distribution process using ET & BA, it was concluded that control measures are necessary for the risks with lower rates, and the effects of risk on humans, environment, capital and equipment must be considered in the risk assessment (14). The method used by them is similar to what used by us. Results showed that the most prominent and highest energy level of risk is related to the effect of water vapor on the environment and safety risks (affecting humans), electrical transformers, and the effect of gasoline on human safety and the environment, respectively. Large dispersion of water vapor in the atmosphere of the production hall, the surface of pools and cooling towers hot-rolled steel industry are known as production process requirements considered as the most important environmental aspects of this industry and the most important corresponding consequences which may lead to loss of energy and corrosion and depreciation of equipment. In Varvara et al., (2009) on 96 cooling towers, 47 devices (48.9%) were infected with Legionella (15) that underlie the transmission of Legionella by cooling towers, although continuous chlorination reduces the risk of transmission; however, adoption of engineering and health safety measures to capture and reuse water vapor is mandatory according to the current crisis. Power transformers also are considered as another sensitive area for activity of the production line in this industry where implementation of the proposed control measures, (including monitoring safety and issuance of work permit, observing the safety distance, training working safety with energized equipment, and establishing safety systems) are effective on reduction of the risk level. This result is consistent with the findings of the study entitled "identification and assessment of risks of high voltage power lines in residential areas" conducted by by Josie et al. In this study, the proposed revisions, such as operator training and regulatory measures are highlighted to reduce the risks (15). In addition, the control and direct supervision of the operations of cooling oil change, which must be done by a certified contractor, plays a key role as a control strategy for prevention of environmental damage from power transformers and reduction of the environmental risk level. Accordingly, gasoline is used as the second fuel of furnace (in case of a pressure drop in methane gas). In such conditions, number of heating convectors and machines inside the complex should be continually monitored and visited in terms of safety and leakage control to protect the environment. Nevertheless, gasoline has no appropriate protection and safety equipment. In doing so, Sarsangi et al., also referred to the cases of violation of safety (13). However, an appropriate safety and insulation control strategy is running in Kavir Steel Complex which plays a preventative role in managing safety and environmental risks of gasoline storage.

One of the unfavorable risks in this study is electromagnetic radiation which is consistent with the results of an epidemiological research on people who were living in the vicinity of electrical tower, or work in the vicinity of magnetic fields. However, adverse consequences are reported such as anemia, lymphoma, melanoma, brain tumor and depression (16). In Parvin Sepehr, the intensity of magnetic fields of control rooms was lower than than standard limits, aiming to measure electric and magnetic fields of control rooms in three Iranian power plants (17), however, observing the proposed safety principles is imperative. Additional risk associated with potential energy is risk of hanging objects (by the action of the crane), uneven surface (the covers for Manholes, Grating amortized, decayed and worn covers), and slider greasy (due to the dispersion of grease and oil on the production hall floor) in Kavir Steel Complex for which many events have been arisen and these items have been ranked as unacceptable and unfavorable risks. In doing so, Mehr Parvar et al., identify some cases such as falling down and hitting the device as the main causes of occupational accidents in Yazd Province of Iran (18). The results of this study and Nasiri et al., where the slipping and hitting with machines are identified as the risks in the workplace, are in line with those of present work in terms of occupational accidents in Kavir Steel Complex. (19). Through a risk assessment using energy trace and barrier analysis method in a foundry, Zahedan et al., show that implementation of safety measures such as safety training, vocational training, inspection monitoring system, contractor safety management, preventive maintenance management system and formation of a safety audit are effective on detection and control of identified risks (20). As a result, most of the mentioned strategies are consistent with a part of the control measures considered in present study in such a way that reduction of the secondary risk according to the proposed control measures is considered as an evidence for this claim (Tables 3 and 4).

By examining the proposed control measures, lack of any understanding and knowledge about the working set of Kavir Steel Complex in terms of safety and environmental issues resulting from the energy-consuming equipment as well as non-indigenous process rather than a working knowledge of the local area can be considered as important reasons for the high percentage of unacceptable and undesirable risks and energy consumption in this industry. Commissioning and documentation of maintenance operations are known as the most effective control strategies in this study and play an important role to reduce the secondary risk level. Implementation of Preventive Maintenance (PM) operations can result in a great consequence as a management tool for controlling the risks and proper functioning of the system (20).

Shirali and Adl conducted a case study on how to implement ETBA techniques in Isomax department of Tehran refinery in which three groups of essential and appropriate corrective measures are mentioned in ETBA sheets which include regular inspections for maintenance and installation of new safety and advanced devices (5). Their reforms are observed in most of the energy risk assessment and control solutions in Kavir Steel Complex.

Conclusion

In the research literature, ETBA has a regular and comprehensive method which is compatible with other system safety methods and is considerably efficient in reviewing and selecting the appropriate option of risk since ETBA method uses a macro and comprehensive perspective to check the safety system (11). However, some sources consider lack of consideration of human error as a disadvantage for this risk assessment method, but this study implies that, although a number of safety hazards is dependent on the kinetic energy (e.g. hanging objects, rough surfaces, elevators, etc.), potential energy (e.g. transport of chemicals, cleaning tanks, etc.) and radiation, the behavior and attitude of manpower for various reasons (i.e. night work, lack of knowledge of safety and environmental issues, lack of safety observation, lack of timely inspection equipment, no understanding on the workplace as a potential for human errors) play a significant role in increasing the risk of a variety of energies.

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